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Special Article

Percutaneous management of posterior malleolar fractures

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Abstract

Posterior malleolar fractures (PMF) are present in up to 44% of ankle fractures. Despite its frequency, there is controversy over the fixation criteria and optimal technique. Historically, fragment size (> 25%) was used as a surgical indication, but today, criteria such as syndesmotic instability, articular step-off, and fragment morphology are used. To synthesize evidence on the percutaneous fixation of PMFs, analyze their indications and risks, compare them with the open approach, and describe the surgical technique preferred by the authors. Percutaneous fixation offers advantages such as the preservation of soft tissues and shorter surgical time in the supine position. However, studies show a higher malreduction rate than open reduction and internal fixation (ORIF) (up to 73% vs. 17%), especially in comminuted or displaced fragments ≥ 5 mm. In single-fragment fractures with minimal displacement, the functional results are comparable. Recent literature suggests that posteroanterior (PA) fixation is biomechanically superior and presents better clinical outcomes and lower rates of osteoarthritis than the anteroposterior (AP) technique. Percutaneous fixation is a valid and effective alternative in selected cases of simple, noncomminuted, minimally displaced PMFs, as well as in patients with low functional demand or soft-tissue compromise. The PA technique stands out for its stability. Success depends on proper computed tomography planning and the surgeon's willingness to convert to an open approach if anatomical reduction is not achieved through indirect maneuvers.

Level of Evidence V; Expert opinion.

Keywords: Posterior malleolus; Ankle fractures; Minimally Invasive Surgical Procedures.

Introduction

Ankle fractures account for up to 10% of all fractures, and posterior malleolar involvement occurs in 7% to 44% of these[1-3]. Posterior malleolar fractures (PMF) are located at the posterior edge of the articular distal end of the tibia and include a wide variety of fracture patterns, being more frequent in the posterolateral edge[4-6].

To analyze PMF, it is essential to complement the evaluation with computed tomography (CT), as this modality allows accurate assessment of anatomy, displacement, and comminution, thereby guiding surgical behavior in approximately one-third of cases[2,7]. However, there is still no consensus on when or how PMF should be treated surgically, or on what degree of malreduction is acceptable without compromising functional outcomes in patients[1,3,6,8,9].

The classic indications for PMF management are based on low-quality evidence and have been questioned as a criterion to define behavior[10] in favor of other parameters, such as tibiotalar or syndesmotic instability, articular step-off, impact, comminution, morphology, and commitment of the

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incision and evidence of better functional outcomes when fixing fragments less than 25% of the articular surface[1,3,11-14]. In addition to the questionable indication for fixing these fragments, there is great heterogeneity in how PMF is handled, particularly with Bartoníček 2 and 3[15].

The objective of this narrative review is to synthesize evidence on the percutaneous fixation of PMFs, analyze their indications and risks, compare them with the open approach, and describe the surgical technique preferred by the authors.

Open approach vs percutaneous fixation

When deciding on posterior malleolus surgery, several factors should be considered during planning. A posterior approach requires the surgeon to position the patient prone, which can make it difficult to treat associated injuries; however, with percutaneous management, the patient can remain supine.

Verhage et al.[3], in a systematic review comparing open and percutaneous management, concluded that there is an increased risk of progression to osteoarthritis in patients with a postoperative articular step-off. The incidence of this articular step-off was 8%-17% with open reduction and internal fixation (ORIF) versus 17%-73% with percutaneous fixation. In addition, better results were reported on the AOFAS scale with ORIF. While this meta-analysis does not provide definitive guidance, it highlights the importance of anatomical reduction for optimal functional outcomes.

On the other hand, the meta-analysis by Wang et al. [13] did not demonstrate differences in clinical scores between the two methods, although they observed a greater reduction, a lower non-union rate, and a greater loss of dorsiflexion with ORIF. In contrast, percutaneous osteosynthesis significantly reduced the risk of infection and neurological injury

Haws et al.[1] evaluated the rate of malreduction in a retrospective series of 120 patients (75.8% ORIF and 24.2% percutaneous). A significant difference was observed in favor of the ORIF (7.7% vs. 24.1% malreduction). After analyzing the risk factors, it was concluded that comminuted fractures or fractures with initial displacement ≥ 5 mm have a higher risk of malreduction with percutaneous treatment. In single-fragment fractures, there were no significant differences across methods. There were no differences in complications or PROMs at 1-year follow-up between the two groups.

Based on this information, we believe that percutaneous management of PMFs has a clear role in treating single, non-displaced, or minimally displaced fragments. This group of patients benefits the most, since the quality of the reduction is not sacrificed, the rigidity associated with subsequent approaches is avoided, and the soft tissues are protected.

Likewise, in patients with low functional demand, advanced age, or with comorbidities that require minimizing surgical aggressiveness, percutaneous management should be considered. In these cases, a suboptimal reduction could be accepted, always after an informed discussion with the patient about the risks and benefits of this choice[16].

Anteroposterior percutaneous screw

Traditionally, the most common indirect fixation technique for PMFs has been the anteroposterior (AP) screw method[7,17]. This technique is ideal for large posterolateral fragments and should be performed prior to definitive fixation of the medial and lateral malleoli to allow better visualization of the articular surface reduction[7].

In Haraguchi type 1 and small fragments, fixation with an AP-cannulated screw is usually considered sufficient[18,19]. In cases of larger fragments, the use of more than one screw may be chosen, at the discretion of the surgeon, to achieve adequate stabilization. Since this technique is strictly dependent on intraoperative imaging support to ensure correct material orientation, it is imperative to consider the concave morphology of the tibial surface and the anatomy of the syndesmosis. The height of the screw is easily evaluated on a lateral radiograph, verifying that its position is extra-articular (with respect to the tibiotalar joint). In addition, this view allows confirmation that the screw length is appropriate and that it crosses the fracture line. To confirm the position in the AP view, the posteromedial vertical syndesmotic line (PVSL) is used as a safety limit to avoid intra-syndesmotic screw placement[20]. The authors also concluded that the PA screw should be located 12 mm medial to the PVSL to avoid injury to the flexor hallucis longus (FHL) tendon. Another issue with this technique is the lack of compression or weak fixation when handling very small fragments, in which the threads cannot cross the fracture line, thereby failing to securely hold the PMFs[21]. Finally, lesions of the tibial and superficial peroneal nerves, the extensor hallucis longus (EHL), the anterior tibial tendons, and the anterior tibial artery have also been described[16,22].

Posteroanterior screw

To address the limitations of percutaneous AP fixation, percutaneous PMF fixation by posteroanterior (PA) screw has gained popularity. Strenge and Idusuyi[23] pioneered a percutaneous PA technique in which the entry point was medial to the anterior tibial tendon. A 1.6 mm anteromedial to posterolateral Kirschner wire (K-wire) was inserted into the ankle during dorsiflexion, and the Achilles tendon was displaced medially to avoid damage. Then, a partially threaded screw is inserted from posterior to anterior. The correct insertion site is crucial to prevent damage to the tibiotalar cartilage when using a PA screw. Using a digital caliper, a prospective study[24] of 100 dry tibia bones showed that screw placement parallel to the tibiotalar joint should be 6 mm and 5 mm above the distal edge of the posterior malleolus for men and women, respectively. If the screw is inserted distal to that reference, they recommended that the screw should be angled 18° and 15° for men and women, respectively, to avoid damaging the articular surface. Although this study was conducted under direct visualization, the results can be applied to the percutaneous technique.

Kimball et al.[25] analyzed the risk of injury in 15 cadaveric specimens using the percutaneous PA technique. The orientation was from the anterior-anterolateral area of the tibia, and a K-wire was advanced in the posterolateral direction. They reported that the sural nerve and peroneal artery had mean wire distances of 5.3 mm (range, 0 to 12 mm) and 5.7 mm (range, 2 to 13 mm), respectively, with no traumatic perforations of either structure. The authors concluded that this technique is a safe alternative with a low risk of tendon and neurovascular injury and recommended it for noncomminuted and minimally displaced fractures and for patients with fragile soft tissues. For their part, Clarke et al.[26] conducted a cadaveric study, where they did not report lesions of neurovascular or tendon structures with this technique, but Czerwonka et al.[27] did report that the sural nerve was in contact with the wire in one specimen, and was sectioned in a second specimen of the 10 evaluated. In addition, the guide-wire pierced the belly of the FHL in four specimens, but the tendon was not damaged by the screw. They concluded that the risk of neurovascular injury was low and suggested using a mini-open approach to protect the sural nerve, and cautioned against using a washer or large-head screws due to the risk of FHL injury.

Percutaneous fixation PA versus AP

The literature comparing percutaneous PA versus AP fixation for PMFs is limited. Yu et al.[28] evaluated 76 patients with trimalleolar ankle fractures of PMF Haraguchi type I. Patients were randomly assigned to percutaneous AP fixation (36 patients) or PA (40 patients), and the authors compared their clinical, radiological, and patient-reported outcomes with a mean follow-up of 30 months. No differences were found between the groups in terms of surgical time, range of motion, or visual analog scale score. However, the rates of severe post-traumatic ankle and articular step-off osteoarthritis were significantly higher in the AP screw group. They concluded that PA fixation is a reliable option for treating Haraguchi type I fractures. It is important to note that in this study, surgeons used medial exposure of the medial malleolus to manually verify posterior malleolar reduction and did not include PMFs Haraguchi types 2 and 3.

Similarly, Mansur et al.[29] compared four types of fixation for PMFs under physiological load conditions using a finite element analysis model: 1) posterior one-third tubular 3.5 mm buttress plate with one screw, 2) the same plate with two screws, 3) two 3.5 mm percutaneous AP screws, and 4) two 3.5 mm percutaneous PA screws. The authors concluded that percutaneous PA screws were biomechanically more stable than AP screws and had lower deformation forces and a lower risk of fixation failure. Recently, a clinical study evaluated the clinical and radiological outcomes of patients with trimalleolar ankle fractures who underwent percutaneous AP (31 patients) and PA (29 patients) fixation for FMP Haraguchi type 1 (follow-up: 25 months). The authors reported fewer articular step-offs, less ankle osteoarthritis, and better clinical outcomes in the PA percutaneous group[30].

Authors' preferred surgical technique for percutaneous PA fixation

Preoperative planning: Anteroposterior, lateral, and mortise radiographs are essential for diagnosing ankle fractures. Likewise, a preoperative ankle CT scan is necessary for decision-making. This approach helps surgeons understand the nature and location of PMF; identify the primary fracture line, presence of intervening fragments, and fragment size, displacement, and establish the ideal reduction technique, including the length and trajectory of the screw in the sagittal and axial planes, in case it is determined that the fracture meets the requirements to be operated on with this technique.

If there is malreduction of the posterior malleolus on preoperative images, the surgeon should be prepared for a failure in ligamentotaxis reduction after fibula fixation. In this case, a periosteum elevator can be inserted through the lateral, posterior approach to the fibula to trap and reduce the posterior malleolus (Figure 1). This maneuver should be performed prior to definitive fixation of the fibula, because a

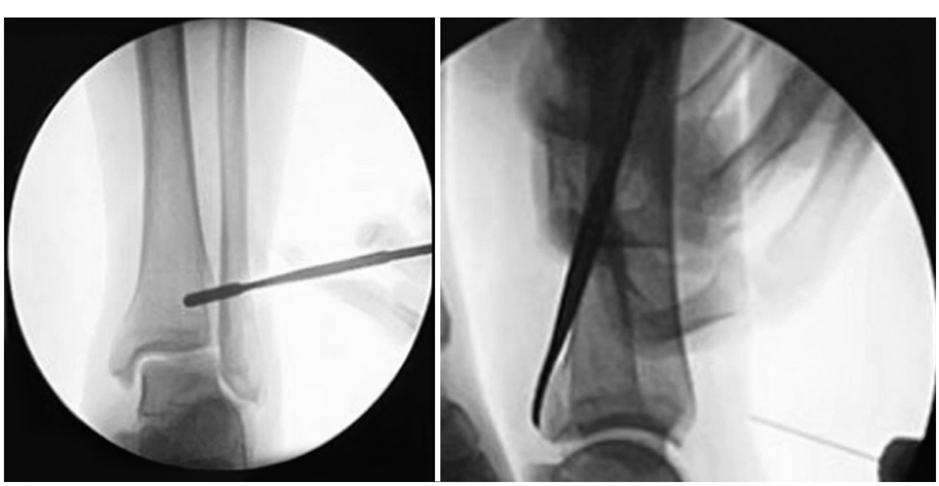

Figure 1. Anteroposterior and lateral ankle radiographs with a periosteal elevator holding the posterior malleolus through a lateral approach.

fibula plate or nail could obstruct fluoroscopic visualization of the reduction. If anatomical reduction of PMF is not possible, we recommend an open posterior approach to obtain adequate results, so you must have the necessary instruments for this conversion.

Positioning and reference points: The patient is positioned supine, with the ankle in a neutral position. An ipsilateral undergluteal enhancement and lowering of the contralateral leg are used to facilitate intraoperative mortise and lateral ankle radiography. Alternatively, the limb to be operated on may be elevated. The medial and lateral malleoli, the joint line, and the Achilles tendon are identified, as well as the anteromedial or anterolateral entry point.

K-wire entry point: Assisted by fluoroscopy, the entry point is generally located proximal to the physiological scar and within the lateral third of the anterior distal tibial articular surface. In this step, we used the PVSL described by Williams et al., which represents the posteromedial edge of the fibular incision on the mortise view, to avoid intrasyndesmotic screw placement. Using a No. 15 scalpel blade, a 1-cm longitudinal incision is made, followed by blunt dissection with a straight mosquito clamp down to the bone. Care must be taken to protect the neurovascular bundle and the extensor tendons at this stage.

K-wire positioning: With a soft-tissue shield, the K-wire is advanced toward the center of the PMF, usually with a head tilt at a low flow rate, as shown in the lateral fluoroscopic view (Figure 2). We recommend holding the PMFs and pushing them from behind with an elevator to prevent displacement when the K-wire enters the PMF (Figure 1). It is important to note that using the elevator to maintain the reduction of PMF is possible in the presence of a fibula fracture that requires a formal lateral approach. If there is no associated fibula fracture, a percutaneous reduction clamp may be used to maintain reduction. Once the posterior cortex of the posterior malleolus is reached, the length of the screw is measured (Figure 3). The K-wire is advanced laterally to the Achilles tendon and past the skin. A second surgeon can displace the Achilles tendon laterally to protect it as the K-wire is advanced. Gently, a plantar flexion of the ankle is performed to ensure that the Achilles tendon is free. The K-wire is secured to a mosquito clamp before piercing (Figure 3).

Anterior to posterior (AP) perforation*:* The K-wire is used as a drill guide for the anterior and posterior cortices of the distal tibia (Figure 3). Again, we recommend pushing the PMFs from the back with an elevator (via a lateral approach, posterior to the fibula) or with percutaneous reduction forceps during drilling to prevent displacement.

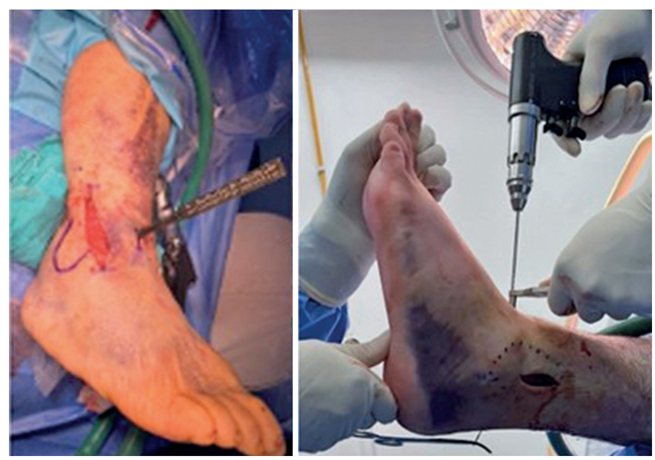

Figure 3. Left image: K-wire length measuring. Right image: Anterior to posterior drilling, with a mosquito clamp securing the K-wire.

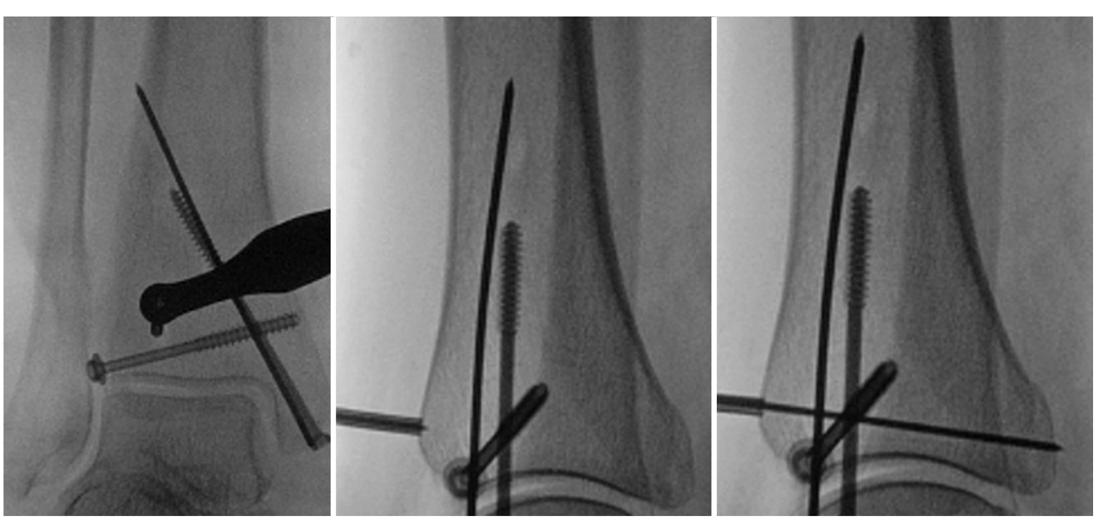

Figure 2. Left and center images: mortise and lateral radiographs showing the K-wire starting point. Right image: lateral radiograph showing the K-wire reaching the posterior cortex of the posterior malleolar fracture.

Screw placement*:* The second surgeon can hold the patient's leg for a comfortable working space. A sharp incision is then made around the K-wire, followed by a blunt dissection with a mosquito clamp to the bone. Through the K-wire, the partially threaded cannulated screw is placed posterior to anterior (Figure 4) until the head of the screw is secured over the posterior cortex, and the position and length are confirmed by lateral fluoroscopy (Figure 5). The use of a washer is optional; however, given the risk of damaging the belly of the FHL, we do not recommend its use.

Closure: Skin closure is recommended, and we perform the procedure with separate nylon stitches.

Figure 4. Posterolateral screw placement in an anterolateral direction.

Conclusion

Percutaneous fixation of posterior malleolus fractures constitutes a valid and effective alternative in selected cases, particularly in simple, non-comminuted fragments with minimal displacement. While current evidence indicates a higher rate of malreduction with open reduction, clinical outcomes appear comparable in well-indicated scenarios. Therefore, rather than a universal technique, percutaneous management should be understood as a tool within the surgical arsenal, with indications based on fracture morphology, soft-tissue conditions, and patient characteristics. In this context, as long as the principles of anatomical reduction and adequate stability are respected, the percutaneous technique can achieve satisfactory outcomes, with the additional benefit of less surgical aggression.

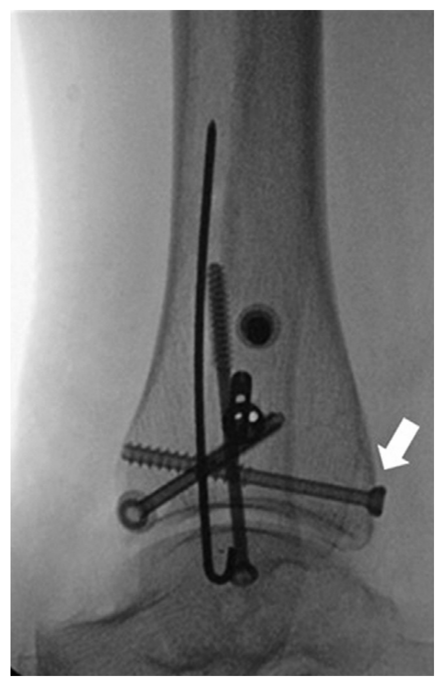

Figure 5. Lateral radiograph showing the final position of the percutaneous posteroanterior screw (white arrow).

Authors' contributions: Each author contributed individually and significantly to the development of this article: UT *(https://orcid.org/0000-0002-1680-8181) Conceived and planned the activities that led to the study, participated in the review process, performed the bibliographic review, formatting of the article, and approved the final version; PJM *(https://orcid.org/0000-0002-6345-1314) Conceived and planned the activities that led to the study, participated in the review process, performed the bibliographic review, formatting of the article, and approved the final version; SM *(https://orcid.org/0000-0002-7766-4097) Participated in the review process, performed the bibliographic review, formatting of the article, and approved the final version; FJ *(https://orcid.org/0000-0002-0222-3086) **:** Participated in the review process, performed the bibliographic review, formatting of the article, and approved the final version. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID) iD.

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